Change Of Routines:
A Multi-Level Analysis

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CHANGE OF ROUTINES: A MULTI-LEVEL ANALYSIS

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Abstract

This paper analyses how organizational routines change. It focuses on the level of learning groups within organizations. The paper starts with a summary of the 'activity theory' of knowledge used. Next, the notion of scripts is used, to analyse organizational groups as 'systems of distributed cognition', and to identify different levels of routines and their change. Finally, the paper looks at communication routines or rules needed for different levels of change, in the formation of new 'shared beliefs'.

Key words: routines, organizational learning, organizational change, evolution, scripts.

Introduction: routines, learning and communities

By 'routines' we understand habitualized configurations of activity. They serve both as the basis for those activities and as repositories of experience from those activities. Routines may be individual or collective, and may be mental or overt. Organizational routines refer to collective patterns of activity, to which several people contribute. Routinized behaviour is typically 'automatic', in the sense of unreflected, and largely based on tacit knowledge, in 'subsidiary' rather than 'focal' awareness (Polanyi 1962, 1966, 1969). Here, the notion of routines connects with Simon's notion of routinized behaviour. As argued by Herbert Simon, tacit, routinized mental routines are rational in the sense of being 'adaptive': they help us to function and survive in a world of uncertainty and bounded rationality. Here, I distinguish two meanings of 'rational conduct'. One refers to the use of reason for deliberative evaluation, in 'calculative behaviour', and the second refers to the adaptiveness of conduct, contributing to survival under uncertainty (which constrains deliberative evaluation). Activity becomes routinized when it has proven to be consistently adequate, or 'satisficing'. The routine is relegated to subsidiary awareness. The downside of routines is that they may become dysfunctional in novel circumstances. When this yields a perceived threat, due to malfunction, routinized behaviour may be shifted, at least to some extent, from subsidiary to focal awareness, for critical, deliberative reflection. As argued by Simon (1983) emotions, such as fear, caused by malfunction, serve to trigger such a shift. This is one reason why emotions are part of rationality, in the sense of adaptiveness. Routines differ from rules in important ways. First, rules tend to be explicit, codified, while routines tend to be more tacit. Second, rules are normative, while routines are habitual, emerging from experience. However, routines are also normative in the sense that new entrants to a community are socialized into its routines. More importantly, rules are generic, generalized, disembedded, abstracted from specific contexts of application. The advantage and purpose of this is that they may then be disseminated across a variety of contexts of application. Their shortcoming is that they are not rich and malleable enough to cope with the complexity and variability of specific contexts of application. That is why 'work to rule' is a form of sabotage. Routines are embedded in contexts of application, which is why they are richer and more tacit than rules. Rules can be absorbed in the development of a routine, but this entails additions of tacit application knowledge, and variations upon the rule. Here, rules can become 'internalized' (Nonaka and Takeuchi 1995) and tacit. Thus one can speak of tacit, routinized rules, but it is important to note that then they are embedded in wider, context-specific, tacit knowledge. Consider the following example.

Some years ago, during a conference in Lisbon, one of us ('I') tried to get money with a bank card from an electronic dispenser. I routinely typed in my pin code, but the machine responded with 'communication disturbed'. That conformed to my prejudice of Portugal as a (then) underdeveloped country, in which telecommunication was likely to be faulty. I tried again ten minutes later. When I got the same response the third time, I started to reflect on what I had been doing: was the error mine, perhaps? Failure shifted the routine from subsidiary to focal awareness. I did not remember my pin code: it was embodied in a habitual movement of my fingers. Then I realized that the number pad was 'upside down'. In the Netherlands the pads count from top to bottom. Here, it was from bottom to top. In my mind I reconstructed my pin code by mentally tapping my fingers on the top to bottom pad. Then I knew my number and could alter the sequence of taps to fit the bottom to top pad. (But after three failures the card was blocked, and I had to borrow money from colleagues). Here, the rule of tapping a code had subsided to a routine, fitting the Dutch context. The rule had to be reconstructed from that context, to be transformed to the new context. I wasn't in Portugal long enough to develop that into a routine.

Nelson and Winter (1982) proposed organizational routines on different levels: routines that govern organizational processes and higher-level routines that govern the change of those lower level routines. This paper elaborates that view, in an analysis of multi-level routines. The change of routines is closely associated with organizational learning. Indeed, a behaviourist (non-cognitive) definition of organizational learning may be the change of organizational routines. As in the work of Nelson and Winter, the literature on organizational learning also considers different levels of learning. In particular, the question is what the differences are between individual learning and organizational learning, and how they are related (Cohen 1991, Cook and Yanow 1993, Weick and Westley 1996).

Individuals have mental routines, and organizations do not. Organizations do have partial, non-mental, codified, abstracted representations of collective routines, in documents such as organization charts, job descriptions, standard operating procedures, algorithms, blueprints, and the like. As argued above, in their use those are embedded in routines, in specific contexts of application, whereby they merge with tacit, context-specific knowledge. Organizations do not have tacit knowledge other than that of individuals. Individuals have partial mental representations (or more accurately: mental constructions) of organizational routines. Individual mental routines are always partially tacit, embedded in individual minds that operate as 'seamless webs' (Quine 1960) of cognition, which constitute their individual 'absorptive capacity' (Cohen and Levinthal 1990). Organizational absorptive capacity is constituted by the totality of individual and collective rules and routines, and the collective ordering of those, in 'distributed cognitive systems' (Hutchins and Klausen 1996; Tsoukas 1996).
'Communities of practice' have been proposed as a crucial intermediate level, between individuals and organization (Brown and Duguid 1960, Wenger and Snyder 2000). Here, individuals connect their individual learning processes, in changes of individual mental routines, to a process of collective learning, in change of collective routines. Brown and Duguid (1960: 60) employ an 'activity-theory' of knowledge (see e.g. Blackler 1995), in which action and learning are intertwined, and they view 'learning as a bridge between working and innovation'. They employ the notion of 'canonical' and 'non-canonical' or 'procedural' (Cohen and Bacdayan 1996) knowledge. Canonical knowledge entails decontextualized, codified and formalized rules for operation. As argued above, such rules cannot cover the richness and the variability of routines in practical contexts. In other words, organizational routines are rarely, if ever, completely codifiable in terms of canonical rules. They are codifiable to some extent, and this may serve as a basis for teaching, but such teaching has to be followed by training, in 'peripheral participation' (Lave and Wenger 1991), for adequate participation in an organizational routine. It is by context-dependent deviations from canonical rules, with the ensuing need for improvisation and experimentation (Brown and Duguid employ Levy-Strauss' concept of *bricolage*) that learning arises, in a change of routines, in interaction between members of the community. This is based on 'storytelling', to capture and share context-bound experience, to guide experimentation. As a result, communities, and routines, emerge from shared work practice rather than that they are designed *ex ante.* Story telling takes an intermediate position between tacit routines and de-contextualized rules. Stories are codified, up to a point, while they still entail strong associations ('triggers') with context-specific tacit knowledge. Stories may be further decontextualized to yield rules. Conversely, when rules are used, they need to yield contextualized stories.
Wenger and Snyder (2000:139, 140) characterize a community of practice as:

> a 'group of people informally bound together by shared expertise and passion for a joint enterprise', which can 'drive strategy, generate new lines of business, solve problems, promote the spread of best practices, develop professional skills, and help companies to recruit and retain talent'.

On the one hand, this characterization is very broad, with a wide scope of activities. In our view there is a need to specify different communities, with different aims and features, with more clarity and precision. On the other hand, the characterization is narrow, in the sense that learning is connected with 'shared expertise, in a joint enterprise'. This seems similar to the view, proposed by Brown and Duguid, that learning emerges from joint practice. We cast the net wider than such communities: there may be groups where learning arises by sharing experience and knowledge, which may be more or less tacit or codified, in other ways than on the basis of shared practice in joint operations. Learning groups may be engaged in a large variety of types, aims and contents of learning, such as: joint production, problem solving, development of new practices or products, exchanging experience from different projects, sharing codified knowledge, the development of skills, training, attitude development, management development, organizational change. Such differences have implications for the structure, functioning and goal achievement of learning groups. For an analysis of how learning groups may be further categorized, see Bogenrieder and Nooteboom (2002). In an analysis of learning groups, they included cognitive issues of 'competence', structural issues of group composition, and problems in the 'governance' of 'relational risk'.
The aim of this paper is to investigate the change of routines, in the development of learning groups or communities. To proceed, we first give a brief summary of the 'activity theory' of knowledge and

learning that we employ (as Brown and Duguid, among others, did). Next, we provide an operationalization of routines in terms of scripts. We use that to analyse 'distributed cognitive systems', different levels of routine change, and 'communication rules/routines' needed for different levels of change, in the development of new 'shared beliefs'.

Knowledge and learning

We take the notions of knowledge and cognition in a wide sense, including perception, interpretation and evaluation, which includes emotion-laden value judgements. In other words, we see cognition and emotion (such as fear, suspicion, grief, excitement) as linked (Merleau-Ponty 1964, Simon 1983, Nussbaum 2001). Note the difference between drives (such as hunger, sex) and emotions. In contrast with drives, emotions are directed not at generalized but at specific objects. Also, emotions are informed by cognition in more detail. For example, fear of something is informed by perception of objects, an attribution of its characteristics, interpretation of events, and causal inferences of threat. Vice versa, emotions also drive cognition. In particular, as indicated before, they trigger a shift of routinized behaviour from subsidiary to focal awareness.

It is a truism to say that information is not the same as knowledge: to become knowledge, information needs to be interpreted and understood in a cognitive framework. Similarly to most researchers in this area, we employ an 'activity theory' of knowledge, and language, that descends from 'symbolic interactionism' in sociology (G.H. Mead), and the view, taken from cognitive psychology, that intelligence is internalized action (Piaget 1970, 1974, Vygotsky 1962, Bruner 1979). Our view is related to other 'constructivist', 'interpretative' or 'hermeneutic' views (cf. Weick 1979, 1995). In contrast with the dominant 'computational representational' view in cognitive science, this leads to the view of knowledge in terms of 'situated action'. Knowledge and the meaning of words are not independent from context. They lie partly in the context of use, and they shift from one context to another. One may still speak of mental 'representations', but only on the understanding that they are mentally constructed, in an embedding in existing cognitive structures and contexts of action, and are not 'given' as any 'mirror image' of reality. Even 'recall' from 'memory' is not simple retrieval, but reconstruction, affected by the context at hand. For a more detailed recent analysis, see Nooteboom (2000).

This process of knowledge construction precludes objective knowledge (or at least any certain knowledge whether or to what extent knowledge is objective). We cannot 'descend from our mind to check how our knowledge is hooked on to the world'. Personal knowledge is embedded in a system of largely tacit, routinized mental categories that constitute absorptive capacity (Cohen and Levinthal 1990). Since mental categories have developed on the basis of interaction with others, in a string of contexts that make up experience, knowledge is path-dependent, and there will be 'cognitive distance' (Nooteboom 1992, 1999) between people with different experience, and cognitive similarity to the extent that people have interacted, in shared experience. Cognitive difference yields both a problem and an opportunity. The opportunity is that we learn from others only when they see and know things differently. In the absence of claims of objective knowledge, interaction with others is the only path we have to correct our errors. The problem, however, is that due to cognitive distance people may not understand each other, and have to invest in understanding.

By 'form' of knowledge we refer to the degree to which knowledge is tacit. Tacit knowledge can never be fully expressed (let alone 'codified'): there is always some loss, due to disembedding from mental systems that are built on personal experience. In other words, knowledge is never identical between people. There are degrees to which dis-embedding takes place in communication. The 'storytelling' that was emphasized by Brown and Duguid carries more context specificity than communication of knowledge that is abstracted into canonical knowledge, where context specificity is shed. Expression by A can be absorbed by B only when B can fit it, or more precisely, reconstruct it, in his/her mental system. And vice versa. In other words, to communicate, A and B must have mutual absorptive capacity that is sufficient to the task at hand. The more shared experience people have, the greater cognitive similarity will be, and communication can take place efficiently, in 'short-hand' communication, with jargon that can be taken for granted, while they do not make sense to outsiders. Greater cognitive difference requires more effort to try and absorb what others do and say, and to

communicate what one says and does in ways that help others to absorb it. That is why newcomers to the group have to start in 'peripheral participation' (Lave and Wenger 1991). This is needed to develop shared tacit absorptive capacity, by 'indwelling in the experiences, perspective, and concepts of other participants' (Von Krogh 1998: 114). As the notion of 'tacit knowledge', the notion of 'indwelling' derives from Michael Polanyi.

Individual learning, especially the learning of highly tacit, procedural, non-canonical knowledge, derives from situated interaction between people. Learning is a social process. However, this does not necessarily yield shared knowledge for a joint purpose. Thus, the aim and result of learning can be individual or collective. In the former, knowledge absorbed from interaction is used elsewhere, and in the latter it is shared or jointly produced for a collective purpose. Some learning groups may be oriented more towards individual learning, and others more to collective learning. We call this the 'level' of learning.

Knowledge can, of course, have different 'contents': professional expertise, skill, work perception and attitude, operation of projects, organization, markets (customers, competition), and 'meta-knowledge' on the location and reliability of sources of knowledge (Wegner et. al. 1985). The object of learning may be generic knowledge, beyond specific applications, or specific, for a given project or practice. We call this the 'scope' of learning. Examples of generic knowledge are: organizational aims, organizational styles projected in role models or myths, collective routines (e.g. accounting procedures), and norms and values of behaviour. Often, generic knowledge will be highly codified, to allow for broad dissemination. However, it is personally interpreted, in specific contexts, as argued above, and then may become tacit. Thus there are diversified interpretations of generic knowledge. Such differences are a source of both error and innovation.

One definition of learning is the ability to respond differently to the same stimuli one had before. However, one might also learn to respond to new stimuli. This is related to the distinction between learning to do existing things better, and to do new things. The first has variously been called first order, single loop learning or learning for exploitation, and the second has been called second order, double loop or exploratory learning (Argyris and Schön 1978, Hedberg et. al. 1976, Fiol and Lyles 1985, Holland 1975, March 1991). We call this the 'depth' of learning. While we can make this conceptual distinction, in the process of learning the two kinds of learning do not stand apart from each other. Exploitation is based on exploration, and vice versa. We exploit what we have explored, and it is on the basis of exploitation that we explore. As Brown and Duguid argued, learning forms the bridge between practice and innovation. A central task of organizations is to find ways of combining the two (Nooteboom 2000). Nevertheless, groups can be primarily aimed at exploitation, which may then yield exploration, or at exploration, which should in due course yield exploitation.

The extent to which the two can be combined in time and place depends on how 'systemic' or 'stand-alone' (Langlois and Robertson 1995) tasks are. In highly systemic tasks, there are many linkages between elements (individual actions), with tight and durable constraints on them, to ensure mutual fit. An example would be a refinery. Here, there is little scope for varying local practice (in separate elements), needed for exploration, without breaking down the integrity of the total system, needed for exploitation. In stand-alone activities, there is scope for local change. An example is a consultancy, with highly autonomous professionals who can vary their practice without disrupting that of others. Of course, there the question is how they can share their knowledge, to avoid the re-invention of wheels, for the sake of efficient exploitation.

Summing up, in knowledge we recognize the following features: content, form (degree of tacitness), and scope (degree of generality vs. specificity). In learning we recognize: cognitive difference, level (individual or collective), and depth (exploitation or more exploration oriented).

Scripts

In order to further develop the notion of a routine, we employ the notion of scripts, which, like routines, we apply to individuals as well as organizations (Gioia and Poole 1984, Nooteboom 2000). Originally, the notion of scripts was proposed on the level of personal mental constructs (Abelson 1976, Shank and Abelson 1977). A script is an ordered structure ('architecture') of sequential and/or parallel component activities called 'nodes' in the script. On an organizational level, in organizational

rather than mental scripts, nodes refer to local ‘communities’. On the level of learning groups or communities, studied here, nodes in a community script refer to (potential) activities of individuals. Nodes entail ‘repertoires’ of action, in the form of a set of ‘subscripts’ (‘subroutines’), from which people contribute to the community script. In this setting, individual ‘capability’ corresponds with a subscript, which includes knowledge and skills. Thus a ‘repertoire’ is a set of subscripts (capabilities embodied in subroutines). We use the notion of scripts to model routines. While routines are what people actually do, scripts are imperfect representations of them. Like all models, and rules, no specification of a script can exhaust what goes on in a routine.

In a script, there are direct connections or ‘linkages’ between nodes when their activities are dependent in any way. The linkages that a node has with other nodes define its ‘role’ in the community. In other words, the architecture of a script defines a set of roles. Neighbouring nodes, i.e. nodes with direct connections of dependence, exert demands on each other, which yield constraints on their connections, yielding constraints on routines. These constraints define boundaries of the ‘task’ of a node. In other words, a role entails a set of linkages and corresponding tasks. The architecture of a community script entails a set of roles. The notion of constraints is our specification of the notion of ‘validation criteria’. The process of ‘validation’ entails the determination of such constraints on linkages.

Each node entails one or more subscripts (which together model a repertoire of routines) for the activities that are contributed, in the node, to the community script. On the level of a node, exploratory learning entails a change of subscripts (capabilities, routines). Within communities, this entails individual learning. Such change is constrained by the constraints on linkages, which provide the boundary conditions of task performance.

People have mental ‘representations’ or models of their own routines, in mental scripts, and of at least part of the collective structure of action (at least the identity of neighbouring nodes). That constitutes their ‘knowledge’, in so far as relevant for the organization. The mental representations that people have, even of their own, individual routines, are not complete, they may be over-complete, in the sense that they may include elements that do not actually form part of their routines, and they may be in error, in the sense of distorting what actually happens. People are not, in general, able to completely codify their mental scripts, which are embedded in the ‘seamless’ and pervasively tacit ‘web’ of their cognition.

Concerning other nodes in a collective script, people need to know at least the constraints on connections with neighbours, e.g. their needs and expectations, in so far as those affect the linkage. In other words, they must know their role and their tasks. They may or may not need to know about the repertoires of routines in other nodes. We will return to that later. Individuals have mental representations of a collective script that may be very incomplete, including only the linkages that concern them directly. If they have a representation of the repertoire of routines of another node, those also may be incomplete and incorrect.

Note that here we run into a conceptual problem. We use scripts as mental or documented models of individual and collective activity, and we proposed that no such model can include all that goes on. Thus, it is problematic to talk of scripts as ‘existing’ objectively. It may exist, but how do we know that we know it correctly? Thus it is problematic to speak of mental representations of a collective script, as we did just now, as if that were objectively identifiable. We should say: people have mental representations of parts of collective activity, which we, authors, assume can be adequately modelled as a script. Perhaps, ‘in the long run’, after exhaustive deliberation, different people could converge on a collective script, as a shared representation of collective activity. However that may be, to avoid awkward, contorted language, we will talk of scripts as if they ‘exist’ as adequate representations of collective activity.

The classic example of a script is a restaurant script (Shank and Abelson 1977). It is a collective script for the overall operation of a restaurant, with nodes of individual activities of both staff and customers. It orders component activities of entry, seating, ordering, cooking, serving, eating, paying and leaving. As in this case, more generally a script is not fully deterministic, since it does not cover all that may happen. It allows for variations in its nodes. For example, one might employ different modes of payment (cash, credit card, debit card, chip card). In some cases the technology of chip cards has not been installed, and some restaurants may not accept credit cards. This script is social, being shared between individuals, but individuals may have non-identical mental representations of it, and they may have different experiences associated with it. Some customers may be used to taking a dog with them,

and this may not always be allowed. It may be included in their mental script of a restaurant, but not in the mental scripts of the staff of a specific restaurant.
In the innovation of a self-service restaurant the order of activities (nodes) is changed (architectural change) into: entry, selection, paying, seating, eating, leaving. Staff nodes no longer include serving, and cooking is more separated from food selection. An important feature of a mental representation of a script is attribution: in a relevant context the observation of one node may trigger the entire script in the mind, and unobserved nodes are attributed to the context. This is one way in which cognition is context-dependent: the context determines which scripts are triggered. This is efficient, for fast pattern recognition, but can yield prejudice.
This elaborates the notion of absorptive capacity (Cohen and Levinthal 1990): one can absorb what one can fit into a relevant mental script. Scripts create but also limit absorptive capacity. A customer who is not familiar with the self-service script may sit first and fail to get food. Individual absorptive capacity is based on mental representations of one's subscripts of action, and of one's mental representation of role, tasks, and, possibly, the roles and tasks of other nodes in the collective script. Mutual absorptive capacity between people entails that they can understand each other's actions, and take appropriate action from their repertoires. Note the difference between partly understanding what others know, and how they think, and having the same knowledge, sharing cognitive categories. The first entails the crossing of cognitive distance, and is known as 'empathy'. The second entails the reduction of cognitive distance, and is known as 'identification'.
Collective absorptive capacity constitutes the ability of the community to absorb events into the collective script (such as actions of customers, in the restaurant script). An important question is how that works: how is this related to roles, tasks, repertoires and mental representations that people have of them? Is it clear what nodes are involved; whose role it is to absorb the event? If it is clear whose role it is, absorption would entail the need for the person involved to absorb the event in his mental representations (i.e. understand it), and from there take appropriate action. What happens if that person does not understand? Is that situation included in his task? What if his/her action would entail a violation of constraints on relations with other nodes, i.e. does not fit his task?

Distributed cognitive systems

In view of our 'situated action', interactionist view of meaning and knowledge, knowledge and learning are seen as 'embedded'. The notion of a script helps to give a specification of cognitive and structural 'connectedness' within a group, and the notion of an organisation as a 'distributed cognitive system'. Learning is embedded in networks, with effects of network structure. Here, we tap into the extensive sociological literature on network structure. This allows us, among other things, to elaborate the distinction between systemic and stand-alone activities. There are three aspects: structure of the network, positions that people take in that structure (see e.g. Coleman 1990), and the strength vs. weakness of ties (Granovetter 1982) between those people. One example of a position that someone takes relative to others lies in the notion of 'legitimate peripheral participation' (Lave and Wenger 1991). Structure is 'dense' when there are many direct linkages between participants, and it is 'sparse' to the extent that there are few such linkages. Related to this, 'structural holes' (Burt 1992) yield a second feature. They refer to gaps in network structure, with parts that are more or less isolated from other parts. There can be such holes within a group, and there are outside holes between groups. Burt argued that density, with many direct ties, yields 'redundancy': there are many ties to maintain, while they yield little added value in access to new knowledge. Strong structural embeddedness (Granovetter 1992), in a dense network, with strong ties, leads to cliques (Janis 1981). In time, that will yield limited cognitive difference, with the danger of 'group think' and lack of innovation. This will be the case especially when group membership is stable, and there are high entry and exit barriers. On the other hand, a dense network yields density of communication (including gossip), as a basis for social control, in monitoring behaviour, a reputation mechanism, and the possibility of coalitions of some members to restrain others (Krackhardt 1999). Structural holes arise, in particular, between different groups. Crossing boundaries between different groups may be perceived as yielding a threat of 'spillover' of knowledge to competing groups. This is part of 'relational risk'. To mitigate such threat, groups may be inclined to close themselves off from outside linkages, or to constrain activities of

boundary spanners. This yields 'closure' as a third feature of groups.[1] Important also, as a fourth feature, is the 'stability' of group membership. Low stability entails frequent exit and new entry of 'outsiders'. A fifth feature of structure is 'centrality': the presence of one or more members that have ties to many other members that themselves have few ties. This has implications for power, in terms of access to alternative members, which has implications for bargaining power, control of information and gossip, coalition formation, and a policy of 'divide and rule'. A sixth feature is 'structural equivalence', that is two or more members that have ties to more or less the same other members. Structurally equivalent members, having the same pattern of ties in the group, may be rivals in the group.

In our view 'strong ties' between members have four aspects. One aspect is 'intensity', which refers to the scope of activities taken up in the tie (share of total activities). The resources that are committed are not necessarily only resources of money, time, or effort, and include psychological resources (commitment, loyalty, fairness, empathy). A second aspect is 'rigidity', with narrow, specific constraints, with lack of flexibility for breaking a tie and establishing ties with others. A third aspect is 'frequency' of interaction, a fourth is 'openness' of communication, and a fifth is 'duration' of the tie. Strong ties yield shared experience, which reduce cognitive difference. Durable ties also have that effect, and they enable the development of empathy and identification (Hansen 1999), as a basis for trust.

Summing up, we recognize six features of structure: density, closure, centrality, stability, structural holes, and structural equivalence. We recognize five aspects of the strength of ties: intensity, rigidity, frequency of interaction, openness of communication, and duration. A systemic activity, as opposed to a stand-alone one, may now refer to density and/or strength of connections, where strength has four aspects. The analysis suggests intermediate forms, between strongly systemic activities and stand-alone ones. In particular, there is a 'modular' structure, with elements that are connected, with some density, but with ties that are not rigid or necessarily durable, with non-specific, generic standards that allow for flexibility of linkages.

The notion of a script also serves to incorporate the notion of 'transactive memory' (Wegner et. al. 1985, Wegner et. al. 1991). This notion is defined as follows (Wegner et.al. 1985:256):

> '(1) an organized store of knowledge that is contained entirely in the individual memory systems of the group members, and (2) a set of knowledge-relevant transactive processes that occur among group members. Stated more colloquially, we envision transactive memory to be a combination of individual minds and communication between them.' (Italics added).

The authors suggest 'a set of communication processes whereby two minds can work as one' (Wegner et. al.1985:263). In transactive memory, various levels of knowledge are assumed – as we also do in the notion of a script. There is 'lower order' knowledge; that is detailed, specialized and knowledge embodied in the subscripts, of individual repertoires of knowledge and skills. This can be paraphrased by the individual's statement 'I know x'. This can include 'know-that' and 'know-how', which can be both tacit and codified, up to a point. Another type of knowledge is 'location knowledge': knowledge about who knows what. The paraphrase here is 'I know that you know x….'. Wegner et. al. assume that location knowledge should be shared between 'minds'/ individuals, in collective transactive memory. This can be paraphrased as: 'I know that you know that I know that you know x…' Shared location knowledge yields the basis for intersubjectivity to develop in a system of distributed cognition (Hutchins and Klausen 1996).

Shared location-knowledge serves the efficiency of knowledge-identification (who knows what) and knowledge 'retrieval'. Experiments by Moreland (1999) seem to affirm these findings. Groups that are jointly trained to learn about the expertise of others seem to perform better. When an individual member enlarges his/her knowledge, this must be communicated to the other members. In this way, all the members of a group have a shared 'directory'.

As indicated, we propose that 'lower-order knowledge' corresponds with mental representations of routines in nodes (which we model as subscripts in a collective script). Shared location knowledge

[1] Note the difference with Coleman's (1990) notion of closure as full density, with everybody linked to everybody else. Here, by closure we understand the warding off of outside connections.

corresponds with knowledge about roles and tasks. We believe that with these distinctions we have a useful framework to conceptualize exploratory learning. It yields a more rigorous specification of (Weick and Roberts 1993:360)'s definition of a collective structure:

'They [people] construct their actions (contribute) while envisaging a social system of joint actions (represent), and interrelate the constructed action with the system that is envisaged (subordinate)' (italics added).

In our specification, the individual's contribution is conceived as depending 1. on the perceived role that one has in the collective script ('represent'), 2. on the tasks that this role entails ('contribute'), and 3. accepting the constraints on actions that this entails ('subordinate').

Levels of exploration

With the notion of a script, we can now identify different kinds or 'levels' of exploration, i.e. change of routines, as follows:

1. Change that preserves existing architecture, existing linkages (roles) and constraints on linkages (tasks).
   1a. with new selections, within nodes, from existing individual repertoires of subscripts (existing individual routines).
   1b. with new capabilities, i.e. new subscripts in individual repertoires, in individual learning , or new participants with different repertoires. At this level of exploration, new staff would have to satisfy existing roles and tasks, by socialization and instruction.

2. Change that preserves existing architecture and existing linkages (roles), with new repertoires (subscripts), from individual learning or new staff, which require change of constraints (tasks), i.e. new validation
   2.a. only local change of constraints for individual nodes (isolated tasks), in stand-alone or modular activity
   2.b. change of constraints (tasks) throughout the architecture, in systemic activity

3. Architectural change with existing nodes and repertoires, in new linkages (roles). Generally, new linkages will entail new constraints (validation).

4. New architecture of old and new nodes, including new capabilities (repertoires), with new linkages (roles) and new constraints (tasks).

Table 1 Types of change

	Type of exploration					
Change	1a	1b	2a	2b	3	4
validation criteria		no	no	local	collective	collective	collective
repertoires of subscripts		no	yes	yes	yes	no	yes
script architecture		no	no	no	no	yes	yes

To illustrate the framework, let us ask which type of exploration occurs in varying project teams of specialists. If different specialists enter with different capabilities (repertoires of subscripts) but in fixed roles with fixed tasks, we have type 1 b. If they have different capabilities, and they are given new tasks, but in the same roles, we have type 2a if there is a change only in their individual tasks, and 2b when tasks change across the whole team. If they enter with existing subscripts in new roles, in a

new team structure, we have type 3. If there is a new team structure, with new roles and development of new subscripts (capabilities), we have type 4.
A survey of changes for different levels of exploration is given in Table 1.
This framework can be seen as a refinement, in terms of scripts, of the work of Henderson and Clark (1990), who recognized similar types of innovation: change that preserves both elements and architecture (1), change of elements in a given architecture (2), change of architecture of existing elements (3), and new architecture with new elements (4).
A central idea now is that in order to maintain exploitation as much as possible during exploration, organizations will proceed from less to more radical forms of change (Nooteboom 2000). One does not engage in further change until both the promise (potential) and need for such change has become manifest. When new repertoires of routines (subscripts, capabilities) are developed, in the first approach they need to submit to constraints imposed on existing linkages (existing tasks). This can severely constrain the utilization of the potential of new capabilities, which can exert pressure to revise constraints (tasks) while preserving the architecture of linkages (roles). First one will try to constrain such change to local adaptations. If even wider changes of constraints are not enough, pressure arises for a change of architecture to yield scope for a full utilization of new repertoires (Nooteboom 2000).
It follows that the need for architectural change depends on how systemic or stand-alone the architecture is. In a systemic script, there are many connections between nodes, with narrow constraints on those connections. In a stand-alone script there are few connections, and in a modular script there are connections, but with slack on constraints. The latter gives more scope for exploration in nodes while preserving the overall architecture for exploitation. In a systemic script, in the sense of having strong ties, with narrow constraints, a violation of constraints occurs more easily, due to their narrowness. If the script is systemic in the sense of being dense, local change has more potential repercussions for other nodes.
We will now use this framework to analyse communication processes in communities for different levels of exploration, i.e. change of routines on different levels. First we turn to the literature for some examples, and then we search for useful concepts and ideas in order to explicate communication processes.

Examples

To get some empirical sense of how exploration and transactive knowledge work, let us consider some examples. The first is taken from Weick and Roberts (1993: 370):

> 'This bos'n, who is responsible for the smooth functioning of deck operations, gets up an hour early each day just to think about the kind of environment he will create on the deck that day, given the schedule of operations. This thinking is individual mind at work, but it also illustrates how collective mind is represented in the head of one person. The bos'n is dealing with collective mind when he represents the capabilities and weaknesses of imagined crewmembers' responses in his thinking, when he tailors sequences of activities so that improvisation and flexible response are activated as an expected part of the day's adaptive response'.

Here, the crewmembers know that the bos'n knows about their skills and this is something that the bos'n knows. On top of this, there is an internalisation of distributed cognition by the individual. The individual contributes while subordinating his contribution to collective action. He does this on the basis of his mental representation of the collective script, or parts thereof. In this particular case, crew members did not need to know their colleagues repertoires. The bos'n knows, and on the basis of that knowledge (re)constructs the architecture of coordination to fit operational needs. In other words, in this case there is no need for everyone to have full location knowledge. Crew members need to know the architecture of the collective script only in so far as it regards their individual actions.
In appears that the situation here is one of limited exploration, in variations within an existing script, with different selections from existing repertoires (exploration type 1a). Perhaps it could also be seen as exploration with novel configurations (sequences) from existing repertoires (exploration type 3), by a central coordinator (the bos'n). The more radical type of exploration (type 4), with a change of both individual and collective routines, under the direction of a central coordinator, is much more

problematic. How can the central coordinator know not only what all participants know but also what they could learn, in mutual interaction?
Another example is the following: an organization involved in research on technology for 'alternative' (durable) energy generation, had various departments with specialized expertise. The organization was a distributed cognitive system. When a new technology needed to be invented for saving energy, cooperation between the departments was weak. Moreover, there were different expectations of the success of a new technology. This organisation used a certain technique (Matheson: The smart organization, HBS Press) in order to create a shared understanding of both the possible contribution of the various departments and their expectations of future success. This yielded a map similar to mental maps often supported by computer simulation (Vennix 1996). In terms of transactive memory, the use of this technique and its publication within the group had two effects: the departments learned about the distribution of knowledge and their possible contributions (relative to estimated success) and this location knowledge was now shared.
Here, the assumption is that existing repertoires, in the different departments, can yield the desired result. Thus, exploration is of type 3. The difference with the previous case is that here there is no central coordinator who knows what everyone knows, and shared location knowledge had to be developed, in a collective mapping procedure. If, however, such repertoires have to be changed, in exploration type 4, the question arises who has to learn what, in a change of repertoire, and what novel architecture such individual learning might yield.

Coordination, identification and shared beliefs

According to our view of knowledge, knowledge and action are intimately connected: knowledge guides action but is also constructed by it. It is crucial not to restrict the analysis to issues of knowledge and to include action and cooperation, in a process of reaching agreement on a common script in an exploratory community. Three types of cooperation are distinguished (Nunamaker et al. 2001).
The first type is described as 'collective effort', with people working on their own, and a group result as the 'sum' (whatever that may be) of individual efforts. This may be the case in a stand-alone structure, with highly autonomous units. A second type is described as 'co-ordinated effort': people still work on their own but their individual efforts are coordinated. Their capabilities may have to change, i.e. they may have to learn. There may be certain points in the course of collaboration where some experts withdraw and others come in. Typically, project groups work in this way. The result of the whole group depends on individual performance plus coordination. There may be different kinds of interdependence (Thompson 1967). One type is 'sequential interdependence' between the various activities. This type of cooperation reflects the descriptions of cooperation in manufacturing networks (Lissoni and Pagani 2000). Another type is 'pooled interdependence', where different units exploit or produce joint resources. A third type of cooperation is described as 'concerted effort': the effort of all members must be performed in synchrony. There exists 'reciprocal interdependence' between parts of the task.
The question arises how different types of cooperation, under different kinds of interdependence, can take place under the condition of cognitive distance and variety, needed to enable learning. One answer comes from social identity theory. This theory states that people prefer to work together with similar others, having similar values, preferences, and interests (Schneider and Northcraft 1999). Here, collaboration is based on cognitive identity (identification). In a situation where such similarity is missing, people look for meta-categorization that could deal with variety. Thus, for example, diversity in ethnic descent could change into commonality by stressing membership of the same nation-state. The essential line of argumentation is that people try to find some shared categories that enable cooperation. Research on the development of cooperation in a (scientific) network would partially support this view (Kreiner and Schultz 1993). As participants carefully approach each other step by step through the exchange of 'gifts', a process of 'getting to know oneself slowly' takes place, which ends (in the most positive case) in a network with reliable participants. In this network norms and sanctions - for example concerning the distribution of rewards - are developed. In this case, people become similar to each as they become members of a coherent group with its own norms, through

processes of self-selection and mutual identification. However, such identification reduces variety and distance of cognition, which hampers exploration.
For example, manufacturing networks are often stabilized structures of cooperation (Lissoni and Pagani 2000). They entail much division of labour. Participants have reached a high efficiency in agreements concerning the distribution of credits or rewards for output in a principal-agent setting (David et. al. 1999, Kreiner and Schultz 1993). The network is highly systemic, with dense and strong ties, and often an authoritative hierarchy within the network, yielding stabilized patterns of cooperation. Typically, there is one central coordinating agent, or technological broker, as a spider in a web (Hargadon and Sutton 1997). This is conducive to efficient exploitation. However, in prolonged interaction, identification may increase, and cognitive distance may decrease, and then loss of exploratory capability arises: '… this efficiency gain may be offset by a loss of research variety if the stability of the network relies upon a particular division of labour among participants' (David et. al. 1999:321).
In sum, identification as an explanatory basis for cooperation seems to block rather than enable exploratory learning. And perhaps identification, with shared (mental representations of) scripts, is not needed. Perhaps empathy is enough: knowing what people can do, and roughly how they think, i.e. having more or less accurate mental representations of other people's repertoires of routines, without necessarily having the same mental scripts. In other words, cognitive distance is preserved, while enabling people to cross that distance by developing appropriate absorptive and communicative capacity.
A second answer, to the question how concerted effort for exploratory learning takes place, is that to enable cooperation under the condition of diversity, at least some common frame of reference must exist, short of full cognitive identity. In order to cooperate, a group must possess a common 'readiness for directed perception' (Boland and Tenkasi 1995:351). Like our approach, this also has roots in social constructivist philosophical schools. That has yielded notions of organizations as 'sensemaking systems' (Weick 1979, 1995), or 'systems of shared meaning' (Smircich 1983) or 'focusing devices' (Nooteboom 1992, 1996). On the level of groups it is referred to as 'perspective making' (Boland and Tenkasi 1995) or mutual 'absorptive capacity' (Cohen and Levinthal 1990) or a 'shared mental model' (Rouse et. al. 1992, Gersick 1988) or 'shared beliefs' (Haas 1992). In order to avoid a semantic jungle, we will use the notion of 'shared beliefs' (as used by Haas) to cover all these notions. These notions are rather vague. What are the objects or dimensions of shared perception, meanings, sense-making? The assumption of shared beliefs appears in the following definition of an epistemic community/exploratory community (Haas 1992:3), which distinguishes various dimensions in shared beliefs:

'An epistemic community is a network of professionals with recognized expertise and competence in a particular domain and an authoritative claim to policy relevant knowledge within a domain or issue-area (…). This network has (1) a shared set of normative and principled beliefs, which provide a value based rationale for the social action of community members; (2) shared causal beliefs, which are derived from their analysis of practices leading contributing to a central set of problems in their domain and which then serve as the basis for elucidating the multiple linkages between possible actions and desired outcomes (3) shared notions of validity- that is intersubjective, internally defined criteria for weighing and validating knowledge in the domain of their expertise; and (4) a common policy enterprise – that is a set of common practices associated with a set of problems to which professional competence is directed, presumably out of the conviction that human welfare will be enhanced as a consequence'. (Italics added.)

Although the author develops this definition as a political scientist, which is especially visible in (4), the definition is applicable also to communities in business. Here, full cognitive identity is not required, just identity in certain aspects (1 to 4). More roughly, Haas distinguishes two central dimensions of shared belief that he considers necessary for cooperation: shared beliefs about social behaviour (what is right and wrong) and shared beliefs concerning the criteria for validation of knowledge.
Pentland (1995: 7) tried to connect the two dimensions of shared beliefs. He argued that behind shared beliefs (about causality and validity), the same 'epistemic criteria' can be identified: 'Epistemic criteria act as rhetorical resources for members of an epistemic community to debate each others' knowledge claims'. The acceptance of shared 'epistemic criteria' is close to the cognitive approaches

mentioned above. However, epistemic criteria here are conceptualised as means that help to structure the interaction that leads to shared belief on norms of behaviour and validity. In other words: Pentland takes one step back, so to speak, beyond shared beliefs to underlying, more general or abstract epistemic principles. This is the general research strategy that we also adopt: rather than assuming shared beliefs, we want to see how they are developed. However, what 'epistemic principles' are at work here? What is the basis for communication?

There is not much literature on the emergence of shared beliefs. Is it a process of self-selection between the members, where members are attracted to each other on the basis of applying the same epistemic criteria? Social identity theory would suggest this approach. Or should shared beliefs be conceived as 'only' the result of negotiation processes, on the basis of existing beliefs? In this case, some essential questions are left unanswered. First, in these approaches 'shared beliefs' between the participants are assumed without explaining the origins. Second, the assumption of shared beliefs seems to go too far. Why, and to what extent, should people share causal and normative beliefs? From a pragmatic perspective, they may have widely varying causal beliefs and norms of behaviour as long as their actions stick together well enough to yield useful results. What, exactly, is meant by validity? Here again we would like to take a more pragmatic approach: ideas and actions are valid when they fit in collective action. Then, the notion of validity is closely associated with our notion of 'constraints' on linkages between nodes in a script i.e. the specification of constraints on tasks. Third, sharing beliefs may hamper exploration, which requires cognitive variety and distance. In fact, the literature indicates that people with functional diversity are likely to differ in their communication and interaction processes (Eisenhardt et. al. 1997, Donnellon 1993).

In our view, most shared beliefs should be considered as the (end-) result of an interaction process and cannot be assumed as a necessary condition at its beginning. The definition of epistemic community given, then, is a static definition that is only applicable *ex post*. Nevertheless, interaction processes presumably require some common basis for communication. What shared beliefs are needed ex ante, as a basis for arriving at shared beliefs about values and corresponding norms of behaviour, common purpose, about content of knowledge and about validation criteria? In an attempt to answer this question, we analyse further concepts from the literature, and next we turn to the dynamics of interaction and communication. There, we adopt the view that all behaviour yields a form of communication (Watzlawick et. al. 1972).

Construction of shared beliefs

So far, we have argued that it goes too far to assume that there are shared beliefs *ex ante,* concerning norms of conduct, causal structures, validity and common enterprise. We argued that in exploration these are mostly not given ex ante, but arise from communicative interaction. We are looking for the communication rules needed for that. We proposed that an important part of such communication rules consists of transactive knowledge, in particular location knowledge. Subsequently, we saw that for some types of exploration it is not needed that everyone knows what everyone knows. Depending on the type of exploration, location knowledge may itself be distributed rather than shared by all. To proceed, we now look in more detail at who has to know what, under what types of exploration, and what the implications are for communicative interaction.

For pure exploitation, and exploration that preserves the architecture and constraints on linkages (exploration type 1), it is not necessary for everyone to know what everyone knows. All one needs to know is who one's existing neighbours are (one's role), and existing constraints imposed on linkages with them (constraints on one's tasks). As we suggested before, from a pragmatic perspective such constraints correspond with the notion of 'validity'. Actions in nodes are valid if they satisfy constraints on linkages with other nodes in the collective script. The process of validation, then, entails the establishment of new constraints, in a reconstruction of tasks. In exploration type 1, that is not needed. In terms of shared beliefs, everyone needs to share beliefs only on existing criteria of validity (the constraints), only with existing neighbours in the collective script. No causal beliefs are needed concerning the repertoires of even neighbouring nodes, as long as they satisfy existing constraints. Here, people are transacting rather than interacting. No development of new shared beliefs is needed. In exploration type 1b it may be a little different. In this type, individuals learn, i.e. extend their

repertoires, or new individuals come in, and neighbours may need to know something about this in order to adapt. A potential problem here is that new options arise from individual learning, whose use may require adaptation of constraints in linkages with one's neighbours. Then, we move to a higher level of exploration.
This yields exploration type 2a, with new repertoires that require only local adaptation of constraints, i.e. new validation. For this, one needs to know the repertoires of neighbouring nodes, in so far as needed to conduct new validation (new constraints), in mutual interaction. This requires not only that one knows what neighbours know, but also that one has sufficient understanding of that for mutual adaptation. That requires a certain mutual absorptive and communicative capacity. In terms of shared beliefs, this entails the development of some shared causal beliefs, concerning repertoires of action, in so far as necessary for validation, but only between neighbours. A new element here, on a 'meta-level', is the possible need to establish shared beliefs on norms of behaviour for interaction and adaptation, according to which validation can take place. This may, however, be local, with mutual adaptation between neighbours. Some locally shared beliefs are also needed on the limits one needs to observe, with regard to 'collective enterprise', so that no wider adaptations are needed, elsewhere in the collective script. A potential problem remains: what if as a result of mutual adaptation neighbours, in turn, need to adapt constraints with their neighbours, resulting in a more pervasive change of constraints, in a collective validation process?
This yields exploration type 2b. This requires mutually consistent validation in multiple connections (across many roles). This requires either some central agent to coordinate multiple validation, or discussion with all other participants. The first may be the case in the first example we discussed in the previous section (the bos'n as a central coordinating agent). The second appears to be the case in the second example (joint development of a new method for saving energy). Here, there is a need to develop collective knowledge of repertoires (location and content knowledge), for which there need to be shared causal beliefs, but only limited, in so far as needed for collective validation. One also needs collective beliefs on norms for interaction, and on the overall architecture of the collective script. A potential problem remains: what if in the existing architecture no overall consistent validation can be achieved, and the architecture of the collective script needs to be changed to achieve coherence?
This yields exploration type 3, with architectural innovation with existing nodes and their repertoires, with new linkages. As in type 2a, there needs to be collective knowledge, in every node, or in a central pool of knowledge, of the location and content of all individual repertoires, and norms for the conduct of mutual adjustment. However, more extensive new knowledge of individual repertoires and procedures is needed, because mutual adjustment goes beyond existing neighbours, to allow for novel linkages. While in existing linkages norms of interaction have stabilized, this may have created an 'in-group' ethic and feeling that now have to be loosened to allow for 'out-group' linkages. Also, a new collective enterprise has to be developed, in a new collective script. How is that to be established? Does it follow from an experimental design from a central authority, or in a process of self-organization? Especially in the latter case, to guide the process of architectural change, shared aims and norms have to be developed. A potential problem here is that to enable a newly emerging script, repertoires in nodes have to be adapted to allow for the new linkages that it requires. In other words, it may require individual learning, or the introduction of new staff with new knowledge.
This yields exploration type 4, with a change of both individual knowledge, in new repertoires, and the development of a new collective script. Here we have a chicken-and-egg situation. Existing repertoires may need to be adapted, but one can identify potential linkages, for a new script, only on the basis of existing repertoires. So, an iterative process of mutual adaptation is needed. This requires iteratively adapted knowledge on the collective script, aims of collective enterprise, norms of interactive conduct, and individual repertoires. This iterative process indicates, precisely, the relation between individual learning (change of subscripts, on the basis of mutual adaptation) and collective learning (formation of a new collective script). In this process, people need to communicate their own repertoires of scripts to others, absorb what they communicate about theirs, they may need to adapt their individual repertoires, and they need to adapt their mental scripts concerning collective script architecture. New norms for conduct have to be developed, iteratively, and new shared views of collective enterprise.

The differences are summarized in Table 2.

Table 2 Construction of new shared beliefs

	Type of exploration					
Type of belief	1a	1b	2a	2b	3	4
validation criteria	no	no	local	collective	collective	collective
location of knowledge	no	local	local	collective	collective	collective
content of knowledge (causal beliefs)	no limited	local limited	local limited	collective	collective extensive	collective iterative
norms of conduct	no	no	local limited	collective limited	collective extensive	collective iterative
collective enterprise	no	no	no	no	collective extensive	collective

Communication rules

As we go to higher levels of exploration, change of routines shifts from specific activities to processes for changing activities. Here, we employ the notion of 'communication rules' for such change. Schall (1983: 56) proposed that:

'Communication rules have been variously defined but, in general, they are considered to be tacit understandings (generally unwritten and unspoken) about appropriate ways to interact (communicate) with others in given roles and situations, they are choices, not laws (though they constrain choice through normative, practical, or logical force), and they allow interactors to interpret behaviour in similar ways (to share meanings).'

According to this, rules of communication seem quite close to routines for communication. As we argued before, we see rules as generic and highly explicit. In time, they are embedded in routines, and thereby become more tacit, in 'tacit understandings … about appropriate ways to interact'. So, at any moment, communication may be based on communicative routines rather than explicit rules. This is the same in language more generally.

When someone has learned a foreign language, at school, this is typically on the basis of formal rules of grammar and syntax. When that knowledge is actually used frequently, it becomes tacit. One may see that a sentence is wrong without being able to specify the rules that it breaks.

When communicative routines are up for change, to be replaced by new ones, this typically (but perhaps not necessarily) requires that the implicit rules are again made explicit, as a de-contextualized abstraction from existing practice to discuss and develop new generic rules, that are subsequently embedded in new routines. Tacit routines are difficult to subject to criticism, because they are taken for granted, as 'evident', precisely because they are tacit.
What communication rules or routines are needed to develop what shared beliefs? Table 2 shows that depending on the level of exploration, communication is needed concerning a variety of subjects:

1. the identity of nodes in a collective script (who's who)
2. connections between nodes, in existing script architecture (roles)
3. constraints on connections, in existing script architecture and roles (boundary conditions for tasks)
4. repertoires of subscripts within nodes (capabilities)

5. norms/routines for interactive conduct concerning change of tasks (validation)
6. norms/routines for interactive conduct for re-configuring roles (role specification)
7. aims of collective enterprise (strategy)
8. norms/routines for interactive conduct for a change of collective aims (strategy formation)

As we go to higher levels of exploration, fewer 'tacit understandings' can be taken for granted, since more and more existing beliefs and 'appropriate ways to interact' are up for change. As a result, communication shifts to 'higher', more abstract levels, to guide the change of lower level routines. What is tacit, on that level, may have to be made explicit to enable critical reflection and change, in the development of new generic rules. The higher the level of exploration, the fewer collective beliefs can be assumed, and the more 'generic' rules need to be, to guide the formation of lower level shared beliefs.
In type 1 exploration, the communication rules include existing script architecture (participants and connections, i.e. roles), and constraints on actions (tasks within roles), embedded in routines. In other words, new routines are invariant with respect to architecture, roles and contraints on tasks. Individual learning or new staff, or new customers, or competitive pressure, may challenge such constraints, exerting pressure for a break of routines.
In type 2 exploration, tasks can no longer be taken for granted, and have to be re-aligned in adaptation of constraints (new validation). Communication rules still include script architecture, including roles. However, they now need to include norms for mutual adaptation for new validation, within existing roles. Existing role structures may obstruct the full utilization of the potential that arises from new tasks.
In type 3 exploration, communication rules no longer include script architecture, which is up for change, and hence neither tasks nor roles. They now need to include norms not only for mutual adaptation of tasks but also for constructing new roles (connections in a new script) from existing repertoires, as well as shared beliefs about the goals of joint enterprise, to guide the formation of a new collective script. That, in turn, may entail gaps in capabilities, and may require individual learning or entry of new staff.
In type 4 exploration, what is new, compared to type 3, is that communication rules no longer include individual repertoires of action, since they also are now up for change, in individual learning, or the entry of new players with different repertoires. Norms or guidelines are now needed for both collective enterprise, to guide new script formation and the direction of individual learning, and for interaction in joint learning. The latter goes beyond new role formation on the basis of existing repertoires. Here, there is a need to adapt absorptive and communicative capacity. This is likely to entail an iterative process, in which beliefs concerning collective enterprise interact with the results of interactive individual learning. In other words, communication rules consist of shared perceptions of strategic goals, and cultural norms for communicating on individual learning, and adjusting absorptive and communicative capacities.
In sum, going to higher levels of exploration entails the change of 'higher' elements of existing collective routines: constraints on tasks, roles, architecture, individual routines. When an element of a routine is changed, the basis for this is a set of higher level rules or routines. Typically, but not necessarily, the lower level change occurs through a new explicit rule, which is then absorbed in new routine formation. On several levels, the question arises where the new rules come from. Are they dictated 'from above', or do they arise from interaction, in 'self-organization'?

Conclusion

Communities form an important intermediate level in organizational learning: they connect individual to collective routines. Communities of exploration are characterized by the use of diverse knowledge. The central question that this paper tried to answer is how cooperation can take place under the condition of cognitive distance within a community. Several conditions have been identified:

1. A community should be viewed as a collective structure of routines of co-ordinated interaction, and not as a purely transactional network.

2. The concept of transactive memory adds that such a collective structure is characterized by (partially) shared location knowledge.
3. Communication rules or routines serve to integrate cognitive diversity on a collective level.
4. Communication rules or routines are changed on the basis of 'higher order' routines or rules for communicative interaction.
5. There are different communicative rules/routines for different levels of exploration. As we move to higher levels of exploration, communication rules shift to higher levels of abstraction. On lower levels of exploration, one can make more use of existing shared beliefs, concerning tasks, roles, distributed knowledge, norms of conduct, and collective enterprise. As we go to higher levels, new shared beliefs have to be developed, first concerning tasks and some norms of conduct, then roles and more extensive norms of conduct, and collective enterprise, then both collective enterprise and interactive learning, in an extension of repertoires for action.
6. When rules have become tacit, embedded in routines, they may have to be made explicit, for critical reflection, in the formation of new rules.
7. The analysis develops the idea that to combine exploitation and exploration as long as possible, one will release and renew shared beliefs step by step, from lower to higher levels of exploration, as needs and opportunities emerge.

Our analysis has been structural and cognitive, and little attention was paid to motivational issues. Under what conditions will people be willing to share knowledge, in view of 'psychological risk', in loss of reputation or 'face', or acceptance in a group, and possible risk concerning salary, career and internal competition for careers within the firm? (Edmonson 1999). How can such risks be mitigated, and how does that depend on the content, purpose, and level of learning and exploration? And how does it depend on role structures? That is a different subject that could not be treated here, but is obviously of crucial importance. Such analysis seems to be needed before we can derive empirically testable hypotheses concerning the emergence of communities for exploration. For such analysis we refer to Bogenrieder and Nooteboom (2002).
In this paper we focused on the level of 'communities', with individual activities as nodes in a community script. Communities, in turn, are embedded as nodes in wider organizational script. Organizations, in turn are embedded in supply chains and other industrial structures. A similar analysis to the one conducted here applies to those higher levels.

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